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## Improved Liquid-Level Sensor for Cryogenics

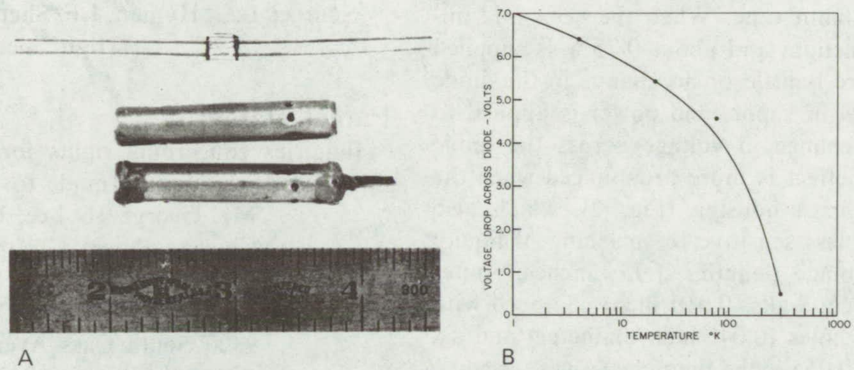


Fig. 1. (A, top to bottom) Diode and resistor thermally connected with aluminum tape, housing, and assembled sensor. (B) Voltage drop across a 1N34A diode as a function of temperature; diode current was 1.00 ma.

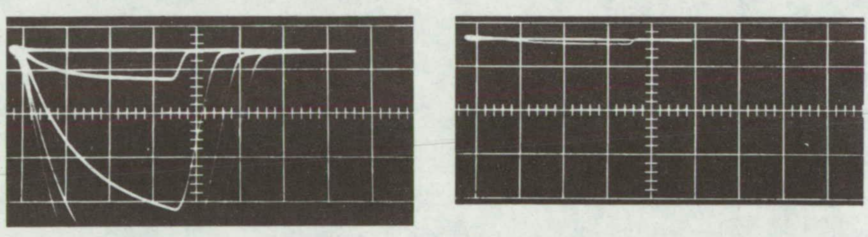


Fig. 2. Responses of voltage across diode in containers in vapor (A) and in liquid (B) as functions of heater power (0.10, 0.40, 0.63, 0.63, 0.78, 0.90 w; 1.00 ma, 19 seconds, 5 seconds per division, 1 v per division).

### The problem:

To develop an ideal liquid-level indicator for a closed and inaccessible cryogenic system. These systems often require the simultaneous use of two or perhaps three of the liquids nitrogen, hydrogen, and helium. Moreover it is customary to precool a helium system with nitrogen and/or hydrogen.

### The solution:

A new liquid-level indicator (Fig. 1A), consisting of a diode heated by a resistor, meets all the requirements. It is rugged, simple, and inexpensive and requires no preselection of components; no elaborate calibration is required, nor adjustment for change in liquid. It is a "yes–no" device that is easy to operate

(continued overleaf)

and interpret. It is insensitive to changes of circuit parameter, and independent of the number of thermal cycles and of environmental conditions such as pressure, geometry, and splashing of liquid. The power dissipated by the indicator is negligible relative to other heat sources in the system. The indicator presents the effects of diode current, resistor power, heater-pulse duration, and liquid pressure.

## How it's done:

Operation of the instrument depends on (i) the strong temperature-dependence of the forward resistance of a germanium diode (Fig. 1B), and (ii) the difference between liquid and vapor in heat-transfer properties.

The basic sensor consists of a 1N34A diode thermally connected to a conventional 0.25-w, 200-ohm carbon resistor serving as the source of heat; they are connected with aluminum tape. When the sensor is immersed in liquid helium and about 0.75 w is supplied to the heater, there is little or no change in the diode voltage; when it is in vapor, and power is applied to the resistor, the change in voltage across the diode is about 5 v. The effect is more pronounced when the sensor is placed in a housing (Fig. 2), which also makes the sensor less sensitive to splashing of liquid; stainless-steel tubing (length, 1.75 inches; outer diameter, 3/16 inch; walls, 0.010 inch) equipped with two liquid-intake holes (0.040-inch diameter) and six gas-vent holes (0.055-inch diameter) was used.

A sensor was thermally cycled rapidly between room and liquid-nitrogen temperature about 100 times with no adverse effects on its behavior. Reproducibly it located the liquid level within less than 1/16 inch, with or without the housing. When the mass flow of gas per unit of time, with the sensor in vapor, was varied, the device proved to be relatively insensitive to the variation.

## Notes:

1. This sensor may interest anyone concerned with cryogenics.
2. Inquiries may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 South Cass Avenue
   Argonne, Illinois 60439
   Reference: B69-10210

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## Patent status:

Inquiries concerning rights for commercial use of this innovation may be made to:

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